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TOTAL TREE AND FIREWOOD WEIGHTS AND VOLUMES OF SCRUB OAKS IN THE GEORGIA SANDHILLS

BY

W. HENRY MCNAB

RESEARCH DIVISION

GEORGIA FORESTRY COMMISSION

AUTHOR

WILLIAM H. McNAB is Silviculturist with the Southeastern Forest Experiment Station at Athens, Georgia. He has a BS degree in Forest Management and MS in Silviculture, both from the University of Florida. He is currently a member of the Utilization of Southern Timber Research Work Unit, where he works mainly on problems related to the effects of silvicultural practices on biomass yields and utilization of forest residues.

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INTRODUCTION

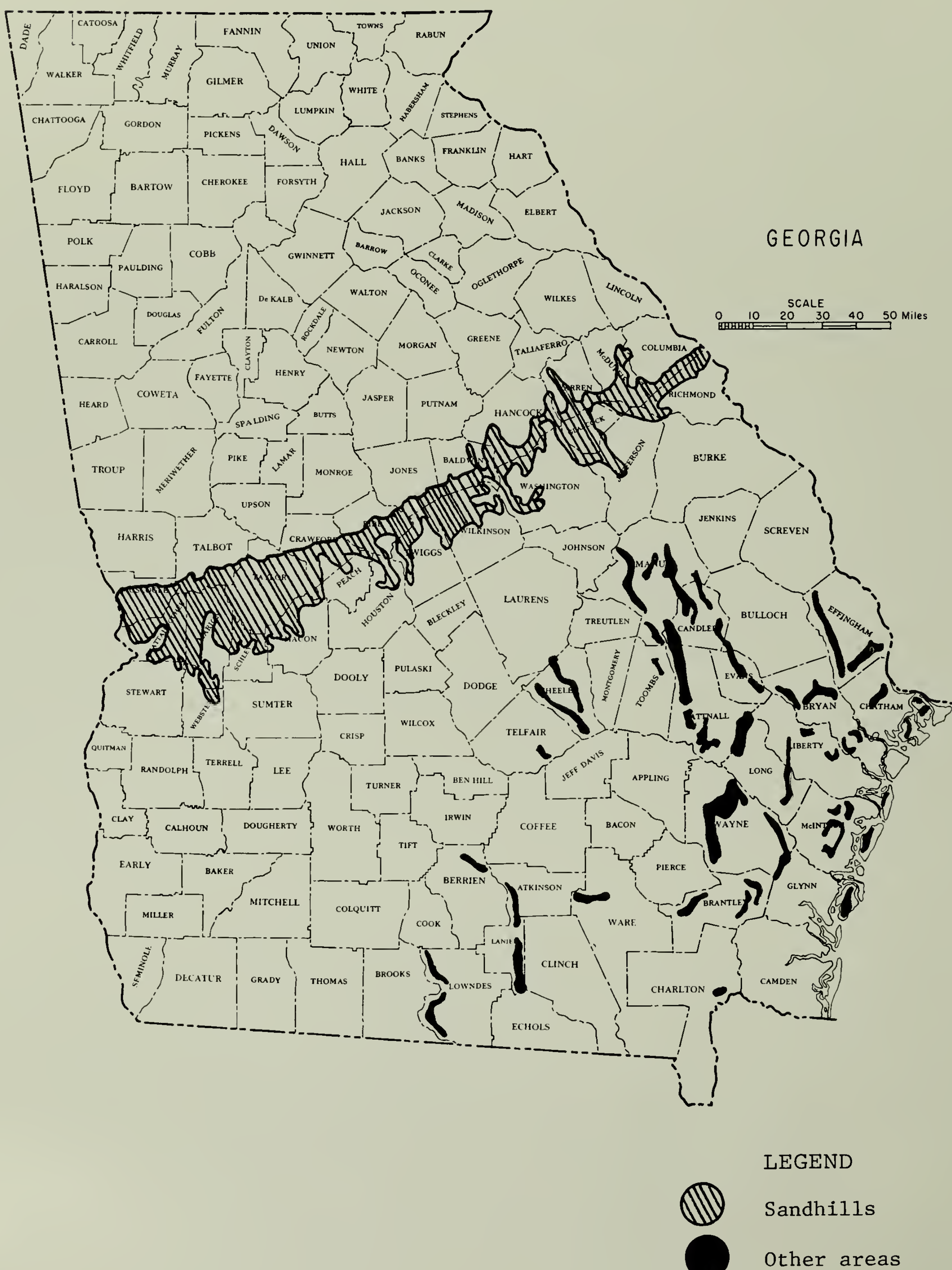
The southern scrub oak forest type, as the name implies, is a mixture of small, poor quality oak species, often with an overstory of scattered longleaf pines. This association typically consists of a mixture of four oak species: turkey oak (Q. laevis), bluejack oak (Q. incana), sand post oak (Q. stellata var. margaretta), and blackjack oak (Q. marilandica). Along the eastern coastal region, sand live oak (Q. virginiana var. geminata) may also be present. This is the smallest hardwood type recognized by the forest survey in Georgia, occupying about ½ million acres. It occurs throughout the State (Knight and McClure 1974), but over 50 percent is in the sandhills physiographic region, a narrow belt of droughty, deep sands separating the Piedmont and Coastal Plains (Figure 1) (Perkins and Shaffer 1977). The sandhills, and scrub oaks, are most extensive in west central Georgia, in Taylor, Marion, and Webster counties. Similar droughty sites are also present in southeastern Georgia along the east side of many coastal plains rivers, particularly the Ogeechee, and on sandstone rock outcrops (Wharton 1980).

Wood production on sandhill sites is marginal from the native oaks, only 20 to 50 cubic feet annually. It can be improved through intensive site preparation and reforestation with sand pine (Preston and Price 1979). Prior to site preparation, scrub oaks are seldom harvested for conventional forest products because they are too small and poorly formed. However, the increased demand for fuelwood may present more opportunity for utilization of scrub oaks by whole tree chipping (Butts and Preston 1979).

Scrub oaks seem to be an ideal fuelwood species; their wood is dense and heavy and they occur on sites which can be harvested year round. Their small size makes them costly to harvest manually, but they are potentially suitable for harvest with mobile whole-tree chippers. In some areas, firewood for the home market may be a more immediately marketable roundwood product. Due to the low value of scrub oaks, no information has been available for estimating their weights and volumes to determine product yield of whole-tree chips or firewood.

To encourage greater utilization of the scrub oak forest resource, a cooperative study with the Georgia Forestry Commission was undertaken to develop the prediction equations and tables contained in this publication. Included here are tables for prism cruising to allow conversion of tree counts directly into biomass estimates (Phillips and Saucier 1981).

Figure 1.--Areas of deep sandy soils in Georgia. The concentration running through the center of the State is called the sandhills. (Map from Perkins and Shaffer 1977).



METHODS

Scrub oaks were sampled at two locations in Georgia: near Butler in Taylor County, and at Fort Gordon in Richmond County. At each location, about 60 trees representing the diameter range of the various oak species were felled for measurement, weighing, and sampling of wood characteristics. In addition to total height, the height to a 2-inch d.o.b. top limit was measured on each tree to obtain the weight and volume of firewood. The entire tree was then weighed on a portable field scale. The branches were then removed and the stem alone was reweighed. Since field work was carried out in November, after leaves had fallen, foliage was not sampled.

A total of 124 trees were sampled, ranging from 0.9 to 6.8 inches d.b.h. and from 9 to 38 feet in height, Table 1. The average age was 28 years and few trees larger than 7 inches d.b.h. were present in the sampled stands. Average green and dry weights of the sample trees are shown in Table 2.

Sample disks were cut from the stem and branches, sealed in plastic bags, and returned to the laboratory for processing. Additional data on wood properties were obtained from the disks, including percent bark by weight, moisture content of wood and bark, and specific gravity of wood and bark. (A computer program was used to calculate cubic volume from the field and laboratory data for each tree.) Data from the four species were combined for analysis to obtain results that would be easy to apply to typical stands of mixed scrub oaks. Prediction equations were developed to estimate weight and volume of the total tree and of firewood from d.b.h. alone and from d.b.h. and total height.

RESULTS AND DISCUSSION

WOOD AND BARK PROPERTIES

The scrub oaks we sampled have properties that make them ideal as fuelwood, Table 3. In comparison to other hardwood species commonly used for fuel, scrub oak wood is denser and drier. Although bark content is somewhat higher than for other species--over 25 percent for the total tree on a green weight basis--bark properties, including heat content, are favorable for use as fuel. For the main stem, bark content ranged from 20 percent for 6-inch d.b.h. trees to 44 percent for 1-inch trees.

TOTAL TREE AND FIREWOOD GREEN WEIGHT

Equations for predicting green weight of wood and bark for the total tree and firewood were developed using d.b.h. alone and in combination with total height. Estimates of green weight of the total tree and firewood to a 2-inch d.o.b. top, based on d.b.h. alone, are presented in Table 4. Similar predicted weights from equations utilizing both d.b.h. and height are presented in Tables 5 and 6. Where the scrub oak stand being cruised has similar diameter to total height relationships as the data utilized for the equations (Table 1), use of d.b.h. alone in a local volume table will provide sufficiently accurate estimates. However, where the mean heights differ by diameter class, more accurate results will be obtained by using total height in the cruise, especially for trees greater than 6 inches d.b.h. The equations presented with tables 5 and 6 can be used to construct a new local volume table for a particular tract, based on d.b.h. alone.

Estimates of dry weight of the total tree or of firewood may be obtained using moisture content data presented in Table 3. Mean moisture content was 65 percent of the dry weight for the wood and bark of the average total tree. Thus, dividing green weights by 1.65 converts green weight estimates to dry weight. For example, Table 4 shows that a scrub oak 5 inches d.b.h will have an average green weight of about 207 pounds; dividing by 1.65 yields a dry weight of about 125 pounds dry. Mean moisture content of the firewood portion of the tree was 66 percent.

The relative amounts of firewood and crown material in scrub oaks are shown in Figure 2. Only small amounts of firewood are present in trees smaller than 3 inches d.b.h. For example, 2-inch trees had less than 1/3 of their weight in stem material, but trees 3 inches d.b.h. and larger, have greater than 50 percent of their weight in stem material or potential firewood.

TOTAL TREE AND FIREWOOD VOLUME

Presented in Table 7 are estimates of total volume and firewood volume based on d.b.h. alone; Tables 8 and 9 show similar estimates using d.b.h. and total height. The data from both tables provide similar estimates of cubic volume around the mean value of tree sampled. However, as previously mentioned for tree weight, height estimates will improve accuracy where the trees being cruised are shorter or taller than the trees we sampled.

These volume tables may be used with locally available factors for converting tree volume to cordwood volume. For example, assuming that a cord of stacked wood contains 76 cubic feet of wood and bark, then a 4-inch tree with 1.15 cubic feet of wood and bark is equivalent to 0.015 cord. About 66 trees of this size would be needed to make a cord of stacked wood.

PRISM CRUISING FACTORS

Prism cruising is a fast and accurate method for estimating both stand basal area and biomass in a single operation. Factors for converting prism cruise data (BAF = 10) to biomass were computed for total tree and firewood weight for individual d.b.h. classes, Table 10. For example, a stand with an average of 30 square feet of basal area in 5-inch trees would contain 22.8 tons per acre of green biomass; 15 tons of the total biomass would be in the form of firewood greater than 2 inches diameter. On the average, there are about 2 tons of biomass per acre for each 3 square feet of scrub oak basal area.

STAND BIOMASS ESTIMATES

Three scrub oak stands of average quality and stocking were cruised at the Fort Gordon site to determine stocking and biomass characteristics. As shown in Table 11, the stands averaged 467 trees per acre with a mean tree d.b.h. of 4.0 inches. The total green biomass was estimated to be 35.8 tons per acre. About 34 tons per acre of biomass are in trees 3 inches d.b.h. and larger. Few stems smaller than 3 inches d.b.h. were present in these three stands, and they contained only about 1 ton per acre of biomass. The biomass harvest is somewhat less than would be available from more fertile sites. However, it is well above the 15-20 green tons per acre estimated to be needed for economical harvest with a mobile biomass harvester such as recently developed by Georgia-Pacific for small trees and brush (Anon. 1980).

If these average quality stands were harvested for solid firewood, they would yield about 9 cords of wood per acre.

Figure 2.--Estimated total green weight of scrub oaks by d.b.h. class, subdivided by firewood and branch components.

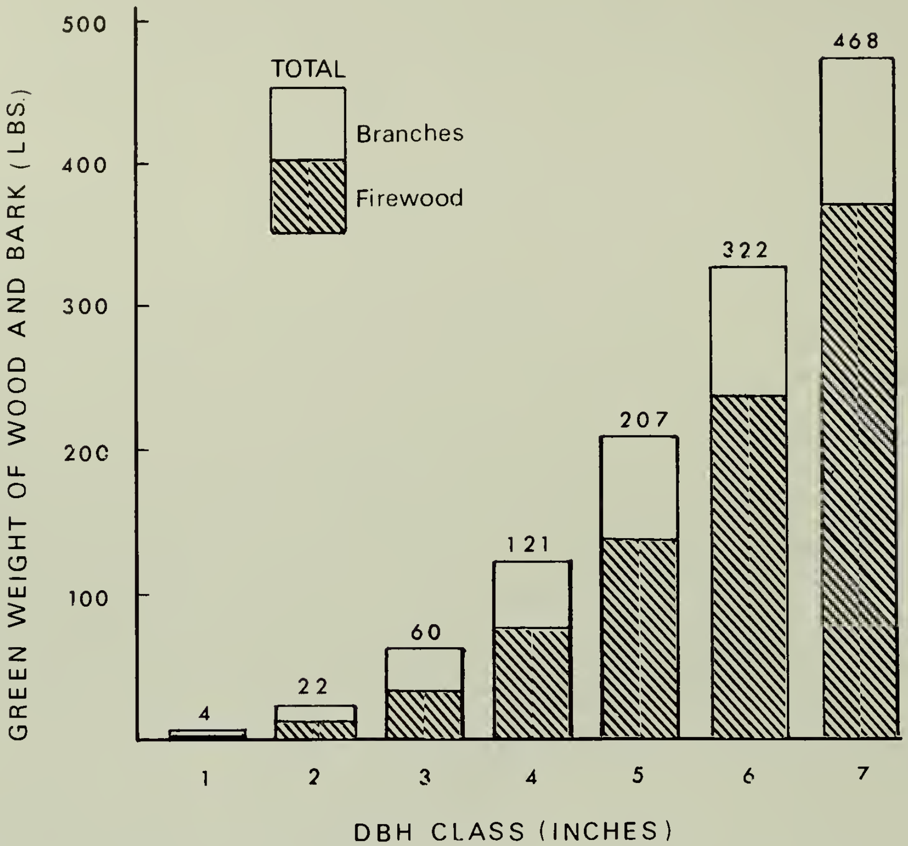


Table 1.-- Means and ranges of d.b.h. and height of the sampled scrub oak trees.

D.b.h. class (Inches)	Sample trees	D.b.h.		Total height		Merch. height		Age Avg.
		Avg.	Range	Avg.	Range	Avg.	Range	
	Number	-- Inches --		------- Feet	------			Years
1	8	1.2	0.9-1.5	11.9	9-14	1.0	0.2- 2.2	18
2	23	2.0	1.6-2.5	17.1	10-22	4.8	1.0-10.1	21
3	25	3.0	2.6-3.5	23.6	18-28	13.0	7.4-18.8	28
4	24	4.1	3.6-4.5	26.5	19-33	17.6	12.3-22.1	29
5	23	5.0	4.6-5.5	29.2	21-37	20.5	15.0-28.0	34
6	15	6.0	5.6-6.5	30.3	24-38	22.2	17.1-28.4	38
7	2	6.7	6.6-6.8	30.5	28-33	21.2	17.0-25.4	35
All classes	124	3.7	.9-6.8	23.8	9-38	14.9	0.2-28.4	28

Table 2.--Average green and dry weight of firewood and the total tree wood and bark for 124 scrub oaks sampled at two locations in Georgia.

D.b.h. class (Inches)	Tree weight		Firewood weight		Volume		Bark proportion
	Green	Dry	Green	Dry	Tree	Firewood	
	Pounds				Cu Ft		Percent
1	6.8	4.2	1.5	1.0	0.11	0.04	43.2
2	23.5	14.3	9.9	6.0	0.36	0.18	36.0
3	62.3	38.0	40.1	24.4	0.94	0.66	29.5
4	129.8	79.0	83.7	50.6	1.90	1.32	27.0
5	219.4	132.6	137.1	82.2	3.24	2.17	26.4
6	337.2	205.5	205.9	123.8	4.91	3.19	26.1
7	411.4	253.5	223.3	136.1	5.89	3.47	27.9
Average	130.8	79.6	83.5	50.4	1.92	1.32	30.5

Table 3.--Physical properties of wood and bark from 124 scrub oaks in Georgia sandhills.

Tree component	Property		
	Moisture content[1/]	Specific gravity	Bark content
	Percent		Percent
Stem			
Wood	70	0.67	22.6
Bark	52	.60	-
Wood & bark	66	.66	-
Branch			
Wood	59	.72	32.4
Bark	73	.57	-
Wood & bark	64	.67	-
Total Tree			
Wood	67	.69	25.9
Bark	59	.59	-
Wood & bark	65	.66	-

[1/] Determined on a dry weight basis.

Table 4.--Predicted total tree and firewood green weight of wood and bark of scrub oaks based on d.b.h. alone.[1]

D.b.h. (Inches)	Tree component	
	Total	Firewood
	Pounds	
1	4	1
2	22	9
3	60	30
4	121	71
5	207	136
6	322	232
7	468	365

[1] Tabular values derived from equations:

$$Y \text{ (total tree)} = 4.20303(D^2)^{1.21089}$$

$$Y \text{ (firewood)} = 1.20425(D^2)^{1.46787}$$

where:

Y = weight in pounds

D = d.b.h. in inches

Table 5.--Predicted green weight of scrub oak total tree wood and bark based on d.b.h. and total height.[1/][2/]

D.b.h. (Inches)	Total tree height							
	10	15	20	25	30	35	40	45
	Pounds							
1	4	5	7	9	10			
2	14	20	26	32	38	44		
3	29	43	56	69	82	94	107	
4	50	73	96	118	140	162	183	205
5	76	111	145	179	213	246	278	311
6		156	205	252	299	346	392	437
7			273	337	399	462	523	584
8				432	513	593	672	750

1/Tabular values computed from equation:

$$Y = 0.42876(D^2H)^{0.93745}$$

where:

Y = weight in pounds

D = d.b.h. in inches

H = total height in feet

2/Blocked-in area indicates range of data.

Table 6.--Predicted green weight of scrub oak firewood wood and bark to 2-inch top based on d.b.h. and total height.[1/] [2/]

D.b.h. (Inches)	Total tree height							
	10	15	20	25	30	35	40	45
	- - - - - - - - - -	- - - - -	- - - - -	- - - - -	Pounds	- - - - -	- - - - -	- - - - - - - - - -
1	1	2	2	3	4			
2	5	8	11	14	17	21		
3	12	20	27	36	44	52	61	
4	24	38	53	69	85	101	118	135
5	40	64	89	115	142	169	197	226
6		97	135	176	215	257	300	343
7			193	249	307	367	427	489
8				338	417	498	581	665

1/Tabular values computed from equation:

$$Y = 0.07019(D^2H)^{1.14954}$$

where:

Y = weight in pounds

D = d.b.h. in inches

H = total height in feet

2/Blocked-in area indicates range of data.

Table 7.--Predicted total tree and firewood cubic volume of wood and bark for scrub oaks based on d.b.h. alone.[1/]

D.b.h. (Inches)	Tree component	
	Total	Firewood
	cubic feet	
1	0.07	0.03
2	.35	.18
3	.91	.53
4	1.79	1.15
5	3.04	2.11
6	4.68	3.45
7	6.75	5.23

[1/] Tabular values derived from equation:

$$Y \text{ (total tree)} = 0.06709(D^2)^{1.18482}$$

$$Y \text{ (firewood)} = 0.02730(D^2)^{1.35056}$$

where:

Y = volume in cubic feet

D = d.b.h. in inches

Table 8.--Predicted volume of scrub oak total tree wood and bark.[1/] [2/]

D.b.h. (Inches)	Total tree height							
	10	15	20	25	30	35	40	45
	cubic feet							
1	0.06	0.09	0.11	0.14	0.16			
2	0.21	0.31	0.40	0.49	0.58	0.67		
3	0.45	0.65	0.84	1.03	1.22	1.41	1.59	
4	0.76	1.10	1.43	1.75	2.07	2.39	2.70	3.01
5	1.14	1.65	2.15	2.64	3.12	3.59	4.06	4.53
6		2.31	3.01	3.69	4.36	5.02	5.68	6.33
7			3.99	4.90	5.79	6.67	7.54	8.40
8				6.26	7.40	8.52	9.63	10.74

1/ Tabular values computed from equation:

$$Y = 0.00714(D^2H)^{0.91840}$$

where:

Y = volume in cubic feet

D = d.b.h. in inches

H = total height in feet

2/ Blocked-in area indicates range of data.

Table 9.--Predicted volume of scrub oak wood and bark firewood to 2-inch top.[1/] [2/]

D.b.h. (Inches)	Total tree height							
	10	15	20	25	30	35	40	45
	- - - - - - - - - - - - - - cubic feet - - - - - - - - - - - - - -							
1	0.02	0.04	0.05	0.06	0.07			
2	0.10	0.15	0.21	0.26	0.32	0.37		
3	0.23	0.36	0.49	0.61	0.74	0.88	1.01	
4	0.43	0.66	0.89	1.13	1.37	1.61	1.85	2.09
5	0.69	1.05	1.43	1.80	2.19	2.57	2.96	3.35
6		1.55	2.09	2.65	3.21	3.78	4.35	4.93
7			2.90	3.67	4.45	5.23	6.02	6.82
8				4.86	5.89	6.93	7.98	9.04

[1/] Tabular values computed from equation:

$$Y = 0.00203(D^2H)^{1.05468}$$

where:

Y = volume in cubic feet

D = d.b.h. in inches

H = total height in feet

[2/] Blocked-in area indicates range of data.

Table 10.-- Factors for converting prism cruise data (BAF = 10) to estimated total tree and firewood weight of scrub oaks in the Georgia sandhills.

D.b.h. class (inches)	Total height	Trees per acre	Tree component	
			Total	Firewood
	feet	number	------tons/10 ft^2 basal area---	
1	11.9	1833	4.0	1.1
2	17.1	458	5.2	2.1
3	23.6	204	6.6	3.4
4	26.5	115	7.2	4.2
5	29.2	73	7.6	5.0
6	30.3	51	7.7	5.6
7	30.5	37	7.5	5.8

Table 11.--Scrub oak tree stocking and estimated green weight of wood and bark by d.b.h. class for three stands sampled at Fort Gordon, Ga.

D.b.h. classes (inches)	Tree stand				Total	
	A	B	C	Mean	Biomass	Firewood
	------trees per acre------				tons/acre	$ft.^3$/acre
1	100	50	17	56	.12	1.5
2	162	50	17	76	.86	13.5
3	162	100	50	50	3.12	55.2
4	50	75	67	64	3.86	73.8
5	25	150	50	75	7.77	158.2
6	38	50	33	40	6.44	138.1
7	12	50	33	32	7.49	167.5
8	0	25	33	19	6.14	142.6
Total	550	550	300	467	35.80	735.4

SUMMARY

Fuelwood is one merchantable product for which small scrub oaks are suitable. The wood of these trees is as dense as hickory and relatively low in moisture--both desirable qualities for fuelwood. The major drawback is the small size of the trees, which will increase harvesting costs. More than 30 tons of green biomass per acre were present in trees 3 inches d.b.h. and larger in the sample stands, which were of average quality.

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